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MANAGEMENT BRIEF

Retention of Passive Integrated Transponder Tags in Stream-Dwelling Rainbow Trout

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Abstract

Passive integrated transponder (PIT) tags have been widely used as a tool for various monitoring and research needs, but the retention of PIT tags has rarely been tested in resident salmonids. We quantified the short-term (≤1 week), annual (1 year), and long-term (≥1 year) retention rates of PIT tags placed in the peritoneal cavity of small resident rainbow trout *Oncorhynchus mykiss* in 11 study streams and assessed whether fish size and gender affected tag retention. Short-term retention rates were at least 92% and averaged 96% for all streams, but a paired *t*-test nevertheless indicated that experienced taggers had significantly higher short-term retention rates (mean, 98%) than did inexperienced taggers (mean, 95%). Annual retention rates for PIT tags averaged 81% among all study streams, ranging from a low of 67% to a high of 92%. Annual retention rates were lower for larger rainbow trout than for their smaller counterparts. Long-term tag loss for females was the same as for males for fish smaller than 15 cm but significantly higher for fish 15 cm or more, suggesting that egg expulsion was the primary cause of tag loss.

Passive integrated transponder (PIT) tags have been widely used to mark individual organisms in various research and monitoring studies. They have been used to mark a variety of fish species for monitoring population characteristics such as growth, mortality, abundance, and movement (e.g., Quinn and Peterson 1996; Hutchings and Gerber 2002; DeHaan et al. 2007; Al-Chokhachy and Budy 2008). When PIT tags are used to study fish population characteristics, the retention rates are assumed to be high but often are not estimated (e.g., Marsh et al. 2005; Rakowitz et al. 2009; Zelasko et al. 2010).

Despite this assumed high retention rate, PIT tag retention is known to be highly variable, depending on a number of factors such as anatomical placement, experience of the tagger, and the size, age, and species of fish being tagged (see review in Dieterman and Hoxmeier 2009). Although widely used for stream-dwelling salmonids, evaluations of PIT tag retention for salmonids in streams are sparse. Retention of PIT tags for adult Arctic grayling *Thymallus arcticus* (>29 cm) was 83% after 3 years for fish tagged in the body cavity (Buzby and Deegan 1999). Retention of PIT tags over 2 months was much lower for brown trout *Salmo trutta* and brook trout *Salvelinus fontinalis* tagged intraperitoneally (56% and 70%, respectively) than for those tagged in the dorsal musculature (95% and 100%, respectively; Dieterman and Hoxmeier 2009). The comparatively lower retention rate in the body cavity most likely is related to spawning activity (Prentice et al. 1990; Bateman et al. 2009), but a major disadvantage of tagging fish in musculature is the increased likelihood that humans might ingest tags implanted in sport fish.

For studies using PIT tag recaptures to estimate fish population characteristics, understanding the factors that affect tag loss and estimating annual retention rates are critical. The main objective of this study was to estimate short-term (≤1 week) annual (1 year), and long-term (≥1 year) retention rates of PIT tags placed in the peritoneal cavity of rainbow trout *Oncorhynchus mykiss*. Specifically, we examined whether (1) tagging experience affected short-term retention, (2) fish size affected annual retention, and (3) fish size and gender affected long-term retention.

METHODS

During the summers of 2006 through 2009, we conducted annual mark–recapture electrofishing surveys in 11 streams across southern Idaho, using either backpack- or canoe-mounted electrofishers. Recapture surveys were made 2–7 days after the marking run. Captured rainbow trout were anesthetized with spearmint oil (solution of 10:1 with ethyl alcohol at 0.3–0.5 mL/L), measured for total length (TL; mm) and weight (g), and in capture runs given a small clip on the caudal fin as an external

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mark for the recapture runs. From 2006 to 2008 we PIT tagged the first 10 fish from each 10-mm size-group, removing adipose fins to indicate that the fish was PIT tagged. Any rainbow trout with an adipose clip from the previous year that had lost its PIT tag was given a new tag. PIT tags (12 mm long, 2 mm diameter; Destron Fearing) were placed intraperitoneally with use of a 12 gauge hypodermic needle. The insertion point was on the ventral side of the body and posterior to the pectoral fin, offset slightly to the right or left side depending on the handedness of the individual tagger. Fish were then put into a recovery tank of fresh stream water until regaining their equilibrium, at which point they were released back into the stream near the point of capture.

Short-term ($\leq$1 week) retention rates were calculated as the proportion of rainbow trout with both adipose and caudal clips that were caught in the recapture run and that contained a PIT tag, in comparison with the total number with both fin clips that were captured in the recapture run. Short-term retention rates were compared between 2006 and 2007 as a comparison between novice and experienced taggers. In 2006, the individuals performing the tagging had no prior experience, whereas in 2007 the same taggers had had one complete year of experience. For all retention rate calculations we assumed no tag malfunction. We used SAS statistical software (SAS 1999) to perform a one-tailed paired *t*-test (Zar 1996) to test our hypothesis that experienced taggers produced higher rates of short-term tag retention; because the data were proportions, we first performed an arcsine square-root transformation on the data before means or statistical tests were calculated (Zar 1996).

We calculated annual (1 year) retention rates from fish that were PIT tagged in 2006 and then recaptured in 2007 during either the marking run or the recapture run, as indicated by a missing adipose fin. Any adipose-clipped fish caught in the recapture run in 2007 that also had a small caudal clip were newly tagged (this small clip had regenerated for 2006 fish) and thus were not included in our calculations. We related annual retention rates to fish length by grouping recaptured fish from 2006 into 10-mm length-groups and calculating a mean retention rate for each length-group. Linear regression was then used to assess the relationship between fish length and mean retention; we used SYSTAT (2004) to weight each length-group by the number of fish in that group. Before statistical analyses, the data were arcsine square-root transformed. No comparison in later years of annual retention rates or of novice versus experienced taggers could be made because fish captured in 2008 and 2009 without tags could not be tied to a specific year of tagging.

To preserve the integrity of an ongoing study in the same study reaches, we could not kill any fish to determine gender until 2009. During the recapture run in 2009, all fish that were PIT tagged in previous years (i.e., had clipped adipose fins) were killed and then transported to the laboratory. Fish were measured (TL) and gender was determined by visual examination of the gonads. We compared long-term ($\geq$1 year) retention rates between males and females by calculating 95% confidence intervals (CIs) around the rates for each gender, following Fleiss (1981); nonoverlapping CIs indicated differences between genders. We divided analysis into two length-groups ($<$15 cm and $\geq$15 cm TL) because we suspected females might lose more tags via egg expulsion, and because rainbow trout often become mature at about 15 cm TL in southern Idaho (Schill et al. 2010).

RESULTS

A total of 4,402 rainbow trout were PIT tagged in 2006, 2,547 of which were caught on the recapture runs and used to estimate short-term PIT tag retention (Table 1). Short-term retention rates were at least 92% for all streams (Table 1), and

TABLE 1. Short-term and annual retention of PIT tags implanted in rainbow trout, by stream.

	Short-term retention			Annual retention		
	Number of clipped fish			Number of clipped fish		
Stream (n)	Recaptured	Recaptured with a PIT tag	Retention rate (%)	Recaptured	Recaptured with a PIT tag	Retention rate (%)
4th Fork Rock Creek	353	341	96.6	73	49	67.1
Willow Creek	183	180	98.4	15	12	80.0
Squaw Creek	89	84	94.4	41	34	82.9
East Fork Weiser River	363	351	96.7	136	113	83.1
Little Lost River	380	364	95.8	87	80	92.0
Middle Fork Boise River	152	145	95.4	61	49	80.3
South Fork Boise River	151	139	92.1	66	44	66.7
Badger Creek	219	218	99.5	82	71	86.6
Little Weiser River	279	275	98.6	81	63	77.8
Clear Creek	191	183	95.8	52	45	86.5
Medicine Lodge Creek	187	182	97.3	112	92	82.1

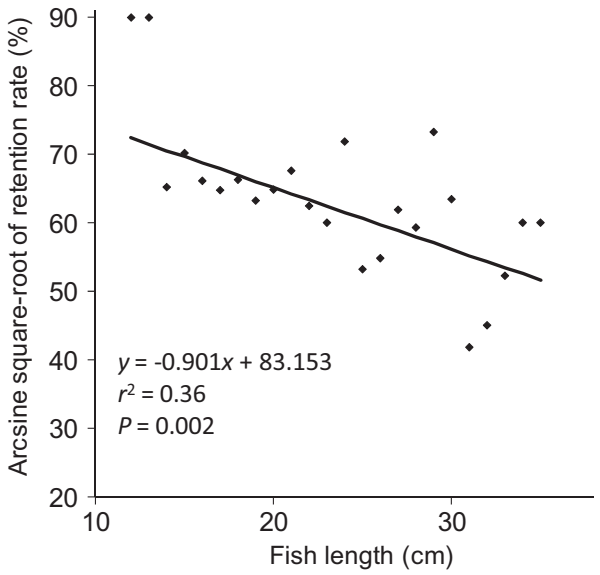

FIGURE 1. Relationship between annual PIT tag retention and total length of rainbow trout. Data for all fish were pooled into 10-mm length-groups and then averaged. The regression line was based on data points weighted by the number of fish in each length-group.

averaged 95% and 98% for novice and experienced taggers, respectively. A paired *t*-test (one-tailed) indicated fished tagged by experienced taggers had significantly higher short-term PIT tag retention than those tagged by novice taggers ($t = 1.81$, df = 10, $P = 0.02$).

In 2007, 806 fish were recaptured that had been PIT tagged in 2006; the mean length of these recaptures was 208 mm (SD = 47; range, 126–371 mm). Annual retention of PIT tags averaged 81% and ranged from a low of 67% in South Fork Boise River to a high of 92% in the Little Lost River (Table 1). Larger rainbow trout had lower annual retention rates than smaller trout did (Figure 1). Data from fish captured and killed in 2009 (n = 353) indicated that long-term loss of PIT tags (i.e., ≥1 year) was associated largely with females. In fact, for fish less than 15 cm TL, long-term retention of PIT tags in females (95 ± 9%; $n = 74$) was virtually the same as in males (94 ± 8%; n = 131); for fish 15 cm long or larger, however, long-term retention in females (67 ± 7%; $n = 74$) was substantially lower than in males (90 ± 4%; $n = 73$).

DISCUSSION

Our results provide strong evidence that for stream-dwelling rainbow trout in southern Idaho, long-term retention of PIT tags inserted intraperitoneally was lower in females than in males, but only when they had reached a size at which sexual maturity occurs. These data support the assumption that egg expulsion may cause much of the loss of PIT tags in salmonids, an assumption that has been based on little empirical data, especially for wild salmonids. Prentice et al. (1990) hand-stripped mature Atlantic salmon *Salmo salar* of milt and eggs in a hatchery setting and found that retention was 100% for all males, and 100% for female nonspawners, compared with 83% for females that released eggs. Dieterman and Hoxmeier (2009) observed low PIT tag retention rates in brook trout and brown trout but found no relationship between loss rates and fish size. They concluded that tag loss was influenced by environmental conditions in the spring during tagging, such as forced swimming during high flows or colder water temperatures that may have delayed healing of entrance wounds. We are unaware of any previous study of wild stream-dwelling salmonids showing increased PIT tag loss in spawning-sized females. PIT tags have been recovered in cutthroat trout *O. clarkii* redds, both from males and females (Bateman et al. 2009), further confirming that expulsion is often related to spawning. However, proportional loss between genders in that study was unknown because gender was largely not monitored. If studies are planned to include spawning-aged salmonids, our results suggest that tag loss will probably increase once sexual maturity is reached, especially for females. More studies like the present one are needed on a variety of species to determine whether this phenomenon is common.

Long-term tag retention was high (95%) for smaller rainbow trout (i.e., <15 cm TL), results similar to estimates from previous studies performed on salmonid populations. These estimates include 97% retention for juvenile steelhead trout *O. mykiss* over 1 month (Bateman and Gresswell 2006), more than 99% retention for juvenile Atlantic salmon for 9 months (Gries and Letcher 2002), and 97% retention for juvenile brown trout after 7 months (Ombredane et al. 1998). However, only the latter study was performed with wild salmonids outside a hatchery.

Short-term PIT tag retention in our study was high (generally >95%) regardless of tagger experience, the difference between novice and experienced taggers being small (3%) and probably of little biological importance in many cases. One-day PIT tag retention for juvenile Chinook salmon *O. tshawytscha* was similarly high (>99%) except for the first of 17 consecutive tagging days, when it was 98.1% (Dare 2003). The author attributed the lower retention on day 1 to tagging inexperience. Tagger experience may also affect retention in areas other than the body cavity, such as in the dorsal musculature (Clugston 1996). In general, our results suggest that even the most inexperienced taggers can achieve very high short-term retention with minimal training. One study limitation was that because we used the same taggers for novice (first year) and experienced (second year) tagging, the treatments occurred in different years, and we cannot rule out that the difference we observed may have been in part related to differences in environmental conditions between years. As mentioned above, Dieterman and Hoxmeier (2009) suggested that swimming conditions during high flow (affecting stability of the PIT tag in the body cavity) and water temperature (affecting healing of entrance wounds) could potentially influence retention rates. However, we deem such an effect unlikely in our study, since all sampling occurred well after spring runoff and the water temperature at the time of sampling any given site on average varied no more than 3°C between 2006 and 2007.

The use of PIT tags has become commonplace for fisheries biologists, providing a means of tracking individual fish over time to estimate fish population characteristics such as mortality, growth, movement, and abundance. However, unaccounted for PIT tag loss will impose bias in many of these estimates. For example, differences over a 3-year period in cutthroat trout survival estimates ranged from 19% to 61%, depending on whether PIT tag loss was corrected or uncorrected (Bateman et al. 2009). If tag loss increases as fish grow and differs between genders after maturity is reached, estimates of some population characteristics could be substantially biased. We concur with Dieterman and Hoxmeier (2009) and Bateman et al. (2009) in recommending the routine estimation of PIT tag retention rate during studies that use this tag to estimate population parameters for stream-dwelling salmonids.

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